

## HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION HVAC/R II

### COURSE DESCRIPTION

*HVAC/R II* is a course in which students will extend their skills and knowledge related to residential and commercial heating, ventilation, air conditioning, and refrigeration (HVAC/R). Topics covered include electricity, thermodynamics, psychometrics, diagnostic, forced air furnaces, air distribution systems, and heating/cooling load analysis. This course gives students a substantial skill and knowledge foundation typically required for apprentice HVAC/R technicians. Course content provides school based and work based learning opportunities for students. Course content prepares students for entry-level employment, advanced training in HVAC/R, and entry into postsecondary education.

*It is strongly recommended that administration and guidance follow the scope and sequence and course recommendations as listed.*

**Recommended:** **Construction Core, HVAC/R I, Algebra I or Technical Algebra, Geometry or Technical Geometry, Principles of Technology I or Physical Science**

**Recommended Credits:** 2

**Recommended Grade Level(s):** 11<sup>th</sup> or 12<sup>th</sup>

**Number of Competencies in Course:** 124

## **HEATING, VENTILATION, AIR CONDITIONING AND REFRIGERATION (HVAC/R II)**

### **STANDARDS**

- 1.0** Students will demonstrate leadership, citizenship, and teamwork skills required for success in the school, community, and workplace.
- 2.0** Students will demonstrate safety practices, including Occupational Safety and Health Administration (OSHA) and Environmental Protection Agency (EPA) requirements.
- 3.0** Students will identify and explain commercial air systems.
- 4.0** Students will identify, describe and perform techniques used for chimneys, vents, and flues.
- 5.0** Students will explain terms and concepts associated with and demonstrate how to perform work on hydronic systems.
- 6.0** Students will recognize parts and accessories for air quality equipment and demonstrate how to install the equipment.
- 7.0** Students will identify and perform leak detection, evacuation, recovery and charging.
- 8.0** Students will identify and explain alternating current.
- 9.0** Students will identify and explain basic electronics.
- 10.0** Students will explain and demonstrate control circuit troubleshooting practices.
- 11.0** Students will explain and demonstrate gas heating troubleshooting practices.
- 12.0** Students will explain and demonstrate cooling troubleshooting practices.
- 13.0** Students will identify heat pumps and demonstrate installation and service procedures.
- 14.0** Students will identify, explain and demonstrate basic installation and maintenance practices.
- 15.0** Students will identify and describe sheet metal duct systems.
- 16.0** Students will describe fiberglass and flexible duct systems.

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

## **STANDARD 1.0**

Students will demonstrate leadership, citizenship, and teamwork skills required for success in the school, community, and workplace.

### **LEARNING EXPECTATIONS**

The student will:

- 1.1** Demonstrate leadership skills.
- 1.2** Use problem-solving techniques to address and propose solutions to school, community, and workplace problems.
- 1.3** Demonstrate the ability to work professionally with others.
- 1.4** Participate in SkillsUSA as an integral part of instruction.
- 1.5** Exhibit integrity and pride in artisanship.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 1.1A** Uses critical-thinking and consensus building skills in group deliberations.
- 1.1B** Keeps group work focused on task.
- 1.2A** Determines the root causes of observed conflicts or problems.
- 1.2B** Mediates disputes between parties.
- 1.3A** Participates in a job shadowing experience.
- 1.3B** Assembles a student team to solve an assigned problem.
- 1.4** Attends and participates in periodic meetings of SkillsUSA or similar organization.
- 1.5** Exhibits integrity and pride in artisanship.

### **SAMPLE PERFORMANCE TASKS**

These are sample projects of the type and scale recommended to address one or more of the learning expectations for this standard. Other projects can be used at the instructor's discretion.

- Prepare a resume.
- Participate in various SkillsUSA or similar programs and/or competitive events.
- Attend a professional organization meeting, such as, local Chamber of Commerce meeting.
- Participate in the American Spirit Award competition with SkillsUSA.
- Participate in job shadowing or internship program with local business or industry.
- Take an active role in a group project assigned by the instructor.
- Identify and detail a problem area in the school, community, or workplace, and propose solutions. If possible, and with appropriate approvals, implement or facilitate the solution.

### **INTEGRATION LINKAGES**

SkillsUSA *Professional Development Program (PDP)*, SkillsUSA, Communications and Writing Skills, Teambuilding Skills, Research, Language Arts, Sociology, Psychology, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Social Studies, Problem Solving, Interpersonal Skills, Employability Skills, Critical-Thinking Skills, SCANS

(Secretary's Commission on Achieving Necessary Skills), Chamber of Commerce, Colleges, Universities, Technology Centers, and Employment Agencies, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), United States Department of Labor, United States Department of Labor *Dictionary of Occupational Titles*, Tennessee Department of Labor and Workforce Development, Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Refrigeration Service Engineers Society (RSES), Plumbing Heating and Cooling Contractors (PHCC), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

### **STANDARD 2.0**

Students will demonstrate safety practices, including Occupational Safety and Health Administration (OSHA) and Environmental Protection Agency (EPA) requirements.

## **LEARNING EXPECTATIONS**

The student will:

- 2.1** Determine safe and correct procedures for working with electricity in heating, ventilation, air conditioning, and refrigeration.
- 2.2** Use protective clothing, eye protection, and safety equipment.
- 2.3** Use fire protection equipment.
- 2.4** Exhibit acceptable dress and personal grooming identified by the heating, ventilation, air conditioning, and refrigeration industry.
- 2.5** Follow Occupational Safety & Health Administration (OSHA), Environmental Protection Agency (EPA) regulations, and manufacturers' specifications according to the heating, ventilation, air conditioning, and refrigeration industry.
- 2.6** Comprehend the importance of a safe work environment.
- 2.7** Passes with 100% accuracy a written examination relating specifically to heating, ventilation, air conditioning, and refrigeration safety issues.
- 2.8** Passes with 100% accuracy a performance examination relating specifically to heating, ventilation, air conditioning, and refrigeration tools and equipment.
- 2.9** Maintains a portfolio record of written safety examinations and equipment examinations for which the student has passed an operational checkout by the instructor.

## **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 2.1A** Conforms to federal, state, local regulations, and manufacturer's specifications when working with electricity.
- 2.1B** Inspects first aid equipment and determines supplies and procedures for electrical injuries.
- 2.1C** Selects, inspects, and uses the correct instruments for working with electrical equipment and systems.
- 2.1D** Selects, inspects, and uses the correct personal protective equipment for working with electrical equipment and systems.
- 2.1E** Understand and explain the effects of voltage on the human body.
- 2.1F** Understand steps necessary to protect co-workers and bystanders from accidental harm from electrical systems during repairs.
- 2.1G** Selects proper Lock-out./Tag-out methods for electrical services and/or equipment.
- 2.2A** Demonstrates proper usage of special safety equipment used while working on heating, ventilation, air conditioning, and refrigeration systems.
- 2.2B** Selects and uses the appropriate protective clothing and eye protection.
- 2.2C** Selects, inspects, and uses the correct personal protective equipment for assigned task.
- 2.2D** Inspects, maintains, and employs safe operating procedures with tools and equipment, such as hand and power tools, ladders, and lifting equipment.
- 2.3A** Identify the four types of fire extinguishers.
- 2.3B** Explain the proper use of each class of fire extinguisher.
- 2.3C** Selects the proper fire extinguisher for an electrical or chemical fire.
- 2.3D** Explain the PASS method (**P**ull, **A**im, **S**queeze, and **S**weep).
- 2.3E** Demonstrates the proper use of a fire extinguisher and determines effectiveness.
- 2.4A** Compares and contrasts acceptable dress and personal grooming for specific jobs in the heating, ventilation, air conditioning, and refrigeration industry.
- 2.4B** Understand the importance of personal hygiene and cleanliness in work and social environments.

- 2.5A** Identify specific safety concerns for the heating, ventilation, air conditioning, and refrigeration industry as defined by the Occupational Safety & Health Administration (OSHA).
- 2.5B** Identify specific regulations and requirements for the heating, ventilation, air conditioning, and refrigeration industry as defined by the Environmental Protection Agency (EPA).
- 2.5C** Complies with relevant regulations and standards pertaining to heating, ventilation, air conditioning, and refrigeration.
- 2.5D** Interprets and applies manufacturers' correspondence for safety procedures.
- 2.5E** Locates regulatory information and manufacturer recall information pertaining to heating, ventilation, air conditioning, and refrigeration systems.
- 2.5F** Interprets and applies Material Safety Data Sheets for chemicals and supplies used in the heating, ventilation, air conditioning, and refrigeration industry.
- 2.6A** Demonstrates continual awareness of potential hazards to themselves and others.
- 2.6B** Provides and activates adequate ventilation equipment as required by the task.
- 2.6C** Researches the effects of substance abuse on performance.
- 2.6D** Operates and maintains tools in accordance with manufacturer's instructions and as required by regulations or instructor.
- 2.7** Passes with 100% accuracy a written examination relating specifically to heating, ventilation, air conditioning, and refrigeration safety issues.
- 2.8** Passes with 100% accuracy a performance examination relating specifically to heating, ventilation, air conditioning, and refrigeration safety issues.
- 2.9** Maintains a portfolio record of written safety examinations and equipment examinations for which the student has passed an operational checkout by the instructor.

### **SAMPLE PERFORMANCE TASKS**

These are sample projects of the type and scale recommended to address one or more of the learning expectations for this standard. Other projects can be used at the instructor's discretion.

- Assess the work area for safety hazards.
- Design a corrections program for identified hazards.
- Explain proper first aid for electrical shock and burns.
- Relate the effects of various levels of voltage on the human body.
- Demonstrate proper Lock-out/Tag-out equipment and procedures for electrical services and equipment.
- Choose proper fire extinguishers for different classes of fires.
- Demonstrate proper fire extinguisher use utilizing the PASS method.
- Model the appropriate protective equipment for an assigned task.
- Demonstrate proper use of personal protective equipment used in working with electrical equipment and components.
- Read manufacturer specifications to determine safe practices while working on various electrical and electronic systems.
- Demonstrate proper tool and equipment use and care.
- Maintain a neat and orderly shop and work area.
- Research the importance of good grooming and personal hygiene in a customer service enterprise and present in class.
- Explain the importance of Confined Space Guidelines under OSHA regulations.
- Demonstrate proper ventilation of an area when dealing with refrigerant gases that are heavier than air.
- Research the effects of substance use and/or abuse on workers in the heating, ventilation, air conditioning, and refrigeration industry.

- Checks shop or work area for possible hazards and plans corrective actions.

### **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA, SkillsUSA *Professional Development Program* (PDP), Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Power Tool Institute (PTI), National Fire Protection Association (NFPA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), American Red Cross, Plumbing Heating and Cooling Contractors (PHCC), National Electrical Manufacturers Association (NEMA), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

### **STANDARD 3.0**

Students will identify and explain commercial air systems.

### **LEARNING EXPECTATIONS**

The student will:

- 3.1** Identify the differences in types of commercial all-air systems.
- 3.2** identify the type of building in which a particular type of system is used.
- 3.3** Explain the typical range of capacities for a commercial air system.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 3.1** Through observation of the equipment, identifies the types of commercial air systems installed in selected buildings.
- 3.2** Given a list of several commercial-type buildings, identifies the type of airside system(s) commonly used in each application. Describe the reason why.

### **SAMPLE PERFORMANCE TASKS**

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### **INTEGRATION LINKAGES**

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## **HEATING VENTILATION AIR CONDITIONING/REFRIGERATION (HVAC/R) II**

### **STANDARD 4.0**

Students will identify, describe and perform techniques used for chimneys, vents and flues.

### **LEARNING EXPECTATIONS**

The student will:

- 4.1** Perform the adjustments necessary to achieve proper combustion in a gas furnace.
- 4.2** Adjust a thermostat heat anticipator.
- 4.3** Calculate the size of a vent required for a given application.
- 4.4** Describe the principles of combustion and explain complete and incomplete combustion.
- 4.5** Describe the content of flue gas and explain how it is used.
- 4.6** Identify the components of a furnace vent system.
- 4.7** Describe how to select and install a vent system.
- 4.8** Describe the techniques for venting different types of furnaces.
- 4.9** Explain the various draft control devices used with natural-draft furnaces.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 4.1** Measures supply and return temperature and determine the temperature rise of a furnace.
- 4.2** Adjusts a thermostat heat anticipator.
- 4.3A** Calculates the correct size and type of PVC pipe using manufacturer's instructions or National Fuel Gas Code or American Gas Association specifications.
- 4.3B** Calculates the correct size and type of furnace vent connector and metal vent using manufacturer's instructions or National Fuel Gas Code or American Gas Association specifications.

### **SAMPLE PERFORMANCE TASKS**

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### **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA, Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Environmental Protection Agency (EPA), Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), Plumbing Heating and Cooling Contractors (PHCC), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

### **STANDARD 5.0**

Students will explain terms and concepts associated with and demonstrate how to perform work on hydronic systems.

### **LEARNING EXPECTATIONS**

The student will:

- 5.1** Identify the major components of hot water heating.
- 5.2** Demonstrate the safety precautions used when working with hot-water systems.
- 5.3** Demonstrate how to operate selected hot-water systems.
- 5.4** Identify common piping configurations used with hot-water heating.
- 5.5** Calculate heating water flow rates.
- 5.6** Select a pump for a given application.
- 5.7** Explain the terms and concepts used when working with hot-water heating.
- 5.8** Explain the purpose of each component of hot-water heating.
- 5.9** Demonstrate how to safely perform selected operating procedures on low-pressure systems.
- 5.10** Read the pressure across a water system circulating pump.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 5.1** Identifies the major components of hot-water heating.
- 5.2** Demonstrates the safety precautions used when working on hot-water systems.
- 5.3** Demonstrates or describe how to safely perform selected operating procedures on hot-water boilers.
- 5.4** Identifies the types of common piping configurations used with hot-water systems.
- 5.5** Calculates heating water gpm requirements from base information provided by the instructor.
- 5.6** Selects a pump from manufacturer's data given the friction loss of a piping system and the gpm requirement from the previous performance task.

### **SAMPLE PERFORMANCE TASKS**

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### **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, Air Conditioning and

Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), American Red Cross, Plumbing Heating and Cooling Contractors (PHCC), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

### **STANDARD 6.0**

Students will recognize parts and accessories for air quality equipment and demonstrate how to install the equipment.

### **LEARNING EXPECTATIONS**

The student will:

- 6.1** Demonstrate how to install and service the humidifiers used in HVAC systems.
- 6.2** Demonstrate how to install and service the filters used in HVAC systems.
- 6.3** Use a manometer or differential pressure gauge to measure the friction loss of an air filter.
- 6.4** Demonstrate or describe how to clean an electronic air cleaner.
- 6.5** Explain why it is important to control humidity in a building.
- 6.6** Recognize various kinds of humidifiers used with HVAC systems and explain why each is used.
- 6.7** Identify accessories commonly used with air conditioning systems to improve indoor air quality and reduce energy cost, then explain the function of each, including: humidity control devices, air filtration devices, and energy conservation devices.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 6.1** Demonstrates and/or describes how to inspect, clean, and replace humidifiers.
- 6.2A** Inspects disposable/permanent air filters for mechanical damage and cleanliness.
- 6.2B** Cleans permanent-type air filters.
- 6.3** Measures the differential pressure drop across an air filter with a manometer.
- 6.4** Demonstrates and/or describes how to clean an electronic air cleaner.

### **SAMPLE PERFORMANCE TASKS**

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### **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Power Tool Institute (PTI), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), American Red Cross, Plumbing Heating and Cooling Contractors (PHCC)

**HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION  
(HVAC/R II)**

**STANDARD 7.0**

Students will identify and perform leak detection, evacuation, recovery and charging.

## **LEARNING EXPECTATIONS**

The student will:

- 7.1** Identify the common types of leak detectors and explain how each is used.
- 7.2** Perform leak detection test using selected methods.
- 7.3** Identify the service equipment used for recovering refrigerant from a system and for recycling the recovered refrigerant, and explain why each item is used. Perform a refrigerant recovery.
- 7.4** Evacuate a system to a deep vacuum.
- 7.5** Identify the service equipment used for evacuating a system and explain why each item of equipment is used. Perform system evacuation and dehydration.
- 7.6** Identify the service equipment used for charging refrigerant into a system and explain why each item of equipment is used.
- 7.7** Charge refrigerant into a system by the following methods: weight, superheat, subcooling, and charging pressure chart.
- 7.8** Use nitrogen to purge a system.

## **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 7.1** Identifies the common types of leak detectors and explain the advantages and disadvantages associated with each type.
- 7.2** Uses selected electronic, ultrasonic, liquid (bubble) and ultraviolet/fluorescent leak detectors to leak test a pressurized operational system.
- 7.3A** Under supervision, uses a recovery and/or recovery/recycle unit to recover the refrigerant from a system.
- 7.3B** Under supervision, uses a mixture of nitrogen and a trace amount of HCFC-22 refrigerant to pressurize a refrigerant system in preparation for leak testing.
- 7.4A** Under supervision, demonstrates and/or describes how to evacuate a system using the deep vacuum method.
- 7.4B** Describes how to perform a vacuum leak test on an evacuated system.
- 7.5A** Under supervision, demonstrates and/or describes how to evacuate a system using the triple evacuation method.
- 7.5B** Under supervision, demonstrates and/or describes how to use dry nitrogen as the moisture-absorbing gas when triple evacuating a system.
- 7.6A** Under supervision, demonstrates and/or describes how to charge a system by weight.
- 7.6B** Under supervision, demonstrates and/or describes how to charge a system using the superheat method.
- 7.6C** Under supervision, demonstrates and/or describes how to charge a system using the subcooling method.
- 7.6D** Under supervision, demonstrates and/or describes how to charge a system using the charging pressure charge methods.

## **SAMPLE PERFORMANCE TASKS**

These are sample projects of the type and scale recommended to address one or more of the learning expectations for this standard. Other projects can be used at the instructor's discretion.

Follow performance tasks in your test booklet.

## **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Power Tool Institute (PTI), National Fire Protection Association (NFPA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), American Red Cross, Plumbing Heating and Cooling Contractors (PHCC), Gas Appliance Manufacturers Association (GAMA), American Gas Association (AGA), Underwriters Laboratory (UL), National Electrical Manufacturers Association (NEMA), National Propane Gas Association (NPGA), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

### **STANDARD 8.0**

Students will identify and explain alternating current.

### **LEARNING EXPECTATIONS**

The student will:

- 8.1** Explain how alternating current is developed and draw a sine wave.
- 8.2** Identify single-phase and three-phase wiring arrangements.
- 8.3** Test AC components, including capacitors, transformers and motors.
- 8.4** Identify the various types of single-phase motors and their applications.
- 8.5** Describe the operation of various types of transformers.
- 8.6** Explain how phase shift occurs in inductors and capacitors.
- 8.7** Describe the types of capacitors and their applications.
- 8.8** Explain the operation of single-phase and three-phase induction motors.
- 8.9** State and demonstrate the safety precautions that must be followed when working with electrical equipment.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 8.1** Identifies components used in AC circuits and explains their functions.
- 8.2** Identifies types of single-phase and three-phase power distribution systems from electrical circuit diagrams.
- 8.3** Following applicable safety practices, tests AC components, including transformers, capacitors, and motor windings.
- 8.4** Identifies various types of AC motors from schematic drawings.

### **SAMPLE PERFORMANCE TASKS**

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### **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), Skills USA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Power Tool Institute (PTI), National Fire Protection Association (NFPA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), American Red Cross, Plumbing Heating and Cooling Contractors (PHCC), Gas Appliance Manufacturers Association (GAMA), American Gas Association (AGA), Underwriters Laboratory (UL), National Electrical



Manufacturers Association (NEMA), National Propane Gas Association (NPGA), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

### **STANDARD 9.0**

Students will identify and explain basic electronics.

### **LEARNING EXPECTATIONS**

The student will:

- 9.1** Describe the operation and function of thermistors and cad cells.
- 9.2** Identify different types of resistors and explain how their resistance values can be determined.
- 9.3** Test semiconductor components.
- 9.4** Explain the basic theory of electronics and semiconductors.
- 9.5** Explain how various semiconductor devices such as diodes, LEDs, and photo diodes work, and how they are used in power and control circuits.
- 9.6** Identify the connectors on a personal computer.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 9.1** Tests a cad cell flame detector.
- 9.2** Tests thermistors.
- 9.3** Tests various semiconductor components.

### **SAMPLE PERFORMANCE TASKS**

These are sample projects of the type and scale recommended to address one or more of the learning expectations for this standard. Other projects can be used at the instructor's discretion.

### **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Power Tool Institute (PTI), National Fire Protection Association (NFPA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), American Red Cross, Plumbing Heating and Cooling Contractors (PHCC), National Electrical Manufacturers Association (NEMA), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

### **STANDARD 10.0**

Students will explain and demonstrate control circuit troubleshooting practices.

### **LEARNING EXPECTATIONS**

The student will:

- 10.1** Explain the function of a thermostat in an HVAC system and describe the different types of thermostats and how they are used.
- 10.2** Demonstrate the correct installation and adjustment of a thermostat.
- 10.3** Identify the various types of electromechanical, electronic, and pneumatic HVAC controls, and explain their function and operation.
- 10.4** Demonstrate how to isolate electrical problems to faulty power distribution, load, or control circuits.
- 10.5** Make electrical troubleshooting checks and measurements on circuits and components common to all HVAC equipment.
- 10.6** Explain the basic principles applicable to all control systems.
- 10.7** Describe a systematic approach for electrical troubleshooting for HVAC equipment and components.
- 10.8** Recognize and use equipment manufacturer's troubleshooting aids to troubleshoot HVAC equipment.
- 10.9** Identify the service instruments needed to troubleshoot HVAC electrical equipment.
- 10.10** Isolate and correct malfunctions in a cooling system control circuit.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 10.1** Identifies various types of thermostats and explain their operations and uses.
- 10.2A** Installs a conventional 24V bimetal thermostat and hook it up using the standard coding system for thermostat wiring.
- 10.2B** Checks and adjusts a thermostat, including heat anticipator setting and indicator adjustment.
- 10.2C** Programs an electronic programmable thermostat.
- 10.3** Identifies electrical, electronic and pneumatic components and circuits, recognize their diagram symbols, and explain their functions.
- 10.4** Interprets control circuit diagrams.
- 10.5A** Performs electrical tests and troubleshooting as follows: single and three-phase input voltage requirements; fuse and circuit breaker checks; resistive and inductive load checks; switch and contractor/relay checks; control transformer checks.
- 10.5B** Performs electrical tests and troubleshooting of compressor and fan motors as follows: starts and runs capacitor checks; starts relay and starts thermistor checks; open, shorted and grounded winding check.

### **SAMPLE PERFORMANCE TASKS**

These are sample projects of the type and scale recommended to address one or more of the learning expectations for this standard. Other projects can be used at the instructor's discretion

## **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA, SkillsUSA *Professional Development Program* (PDP), Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Power Tool Institute (PTI), National Fire Protection Association (NFPA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), American Red Cross, Plumbing Heating and Cooling Contractors (PHCC), National Electrical Manufacturers Association (NEMA), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

### **STANDARD 11.0**

Students will explain and demonstrate gas heating troubleshooting practices.

### **LEARNING EXPECTATIONS**

The student will:

- 11.1** Interpret control circuit diagrams for gas heating systems.
- 11.2** Identify the tools and instruments used when troubleshooting gas heating.
- 11.3** Isolate and correct malfunctions in gas heating systems.
- 11.4** Describe the basic operating sequence for gas heating equipment.
- 11.5** Describe the operation of various types of burner ignition methods.
- 11.6** Demonstrate using the tools and instruments required for troubleshooting gas heating systems.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 11.1** Analyzes control circuit diagram(s) for a selected gas heating appliance.
- 11.2A** Identifies the tools and instruments needed to troubleshoot a gas heating appliance.
- 11.2B** Develops a checklist for troubleshooting a gas heating appliance.
- 11.3** Isolates and corrects malfunctions in a gas heating appliance: control circuits, combustion system, safety controls, air system.

### **SAMPLE PERFORMANCE TASKS**

These are sample projects of the type and scale recommended to address one or more of the learning expectations for this standard. Other projects can be used at the instructor's discretion.

### **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA, SkillsUSA *Professional Development Program* (PDP), Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Power Tool Institute (PTI), National Fire Protection Association (NFPA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), American Red Cross, Plumbing Heating and Cooling Contractors (PHCC), National Electrical Manufacturers Association (NEMA), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

## **STANDARDS 12.0**

Students will explain and demonstrate cooling troubleshooting practices.

### **LEARNING EXPECTATIONS**

The student will:

- 12.1** Describe a systematic approach for troubleshooting cooling systems and components.
- 12.2** Recognize and use equipment manufacturer's troubleshooting aids to troubleshoot cooling systems.
- 12.3** Identify and use the service instruments needed to troubleshoot cooling systems.
- 12.4** Successfully troubleshoot selected problems in cooling equipment.
- 12.5** Isolate problems to electrical and/or mechanical functions in cooling systems.
- 12.6** State the safety precautions associated with cooling troubleshooting.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 12.1** Develops a checklist for troubleshooting cooling systems.
- 12.2** Analyzes control circuit diagram(s) for a selected cooling system.
- 12.3** Identifies the tools and instruments needed to troubleshoot a cooling system.
- 12.4** Isolates and corrects malfunctions in a cooling system: electrical problems, compressor electrical failures, system-related compressor problems, refrigerant overcharge and undercharge, evaporator and condenser problems, metering device problems, refrigerant lines and accessories, noncondensibles and contamination.

### **SAMPLE PERFORMANCE TASKS**

These are sample projects of the type and scale recommended to address one or more of the learning expectations for this standard. Other projects can be used at the instructor's discretion

Follow performance tasks in your test booklet.

### **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA, SkillsUSA *Professional Development Program* (PDP), Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Power Tool Institute (PTI), National Fire Protection Association (NFPA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), American Red Cross, Plumbing Heating and Cooling Contractors (PHCC), National Electrical Manufacturers Association (NEMA), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

### **STANDARD 13.0**

Students will identify heat pumps and demonstrate installation and service procedures.

### **LEARNING EXPECTATIONS**

The student will:

- 13.1** List the components of heat pump systems.
- 13.2** Describe the role and basic operation of electric heat in common heat pump systems.
- 13.3** Demonstrate heat pump installation and service procedures.
- 13.4** Analyze a heat pump control circuit.
- 13.5** Describe the principles of reverse-cycling heating.
- 13.6** Identify heat pumps by type and general classification.
- 13.7** Describe various types of geothermal water loops and their application.
- 13.8** Describe common heat pump ratings, such as Coefficient of Performance (COP), Heating Season Performance Factor (HSPF), and Seasonal Energy Efficient Ratio (SEER).
- 13.9** Identify and install refrigerant circuit accessories commonly associated with heat pumps.
- 13.10** Isolate and correct malfunctions in a heat pump.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 13.1** Identifies components that are unique to heat pumps and explains the function of each.
- 13.2** Calculates the balance point of a heat pump.
- 13.3A** Simulates/describes the installation procedures for a heat pump.
- 13.3B** Performs heat pump servicing procedures.
- 13.4** Analyzes a heat pump circuit diagram and performs simulated troubleshooting exercises.

### **SAMPLE PERFORMANCE TASKS**

These are sample projects of the type and scale recommended to address one or more of the learning expectations for this standard. Other projects can be used at the instructor's discretion.

Follow performance tasks in your test booklet.

### **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Power Tool Institute (PTI), National Fire Protection Association (NFPA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), American Red Cross, Plumbing Heating and Cooling Contractors (PHCC), National Electrical Manufacturers

Association (NEMA), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)



## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

### **STANDARD 14.0**

Students will identify, explain and demonstrate basic installation and maintenance practices.

### **LEARNING EXPECTATIONS**

The student will:

- 14.1** Identify, explain and install threaded and non-threaded fasteners.
- 14.2** Identify, explain, remove and install types of gaskets, packings and seals.
- 14.3** Identify types of belt drives, explain their uses, and demonstrate procedures used to install or adjust them.
- 14.4** Identify and explain types of couplings.
- 14.5** Demonstrate procedures used to remove, install and align couplings.
- 14.6** Identify types of bearings and explain their uses.
- 14.7** Demonstrate procedures used to remove and install bearings. Explain causes of bearing failures.
- 14.8** Identify types of lubricants and explain their uses. Use lubrication equipment to lubricate motor bearings.
- 14.9** List ways to develop and maintain good customer relations.
- 14.10** Perform basic preventative maintenance inspection and cleaning procedures.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 14.1A** Identifies types of threaded fasteners.
- 14.1B** Identifies types of non-threaded fasteners.
- 14.2A** Identifies different types of gaskets.
- 14.2B** Identifies mechanical seal parts.
- 14.2C** Installs an oil seal.
- 14.3** Aligns and properly adjusts V-belts.
- 14.4** Identifies different types of drive couplings.
- 14.5** Tighten a four-bolt flange.
- 14.6** Identifies different types of bearings.
- 14.7A** Recognizes and uses a manual bearing puller to remove a bearing.
- 14.7B** Recognizes and uses a feeder gauge to measure bearing clearances.
- 14.8** Lubricates a bearing using a lever-type grease gun.
- 14.9** Fills out typical forms used for installation and service calls.

### **SAMPLE PERFORMANCE TASKS**

These are sample projects of the type and scale recommended to address one or more of the learning expectations for this standard. Other projects can be used at the instructor's discretion.

### **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS),

SkillsUSA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Power Tool Institute (PTI), National Fire Protection Association (NFPA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), American Red Cross, Plumbing Heating and Cooling Contractors (PHCC), National Electrical Manufacturers Association (NEMA), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

### **STANDARD 15.0**

Students will identify and describe sheet metal duct systems.

### **LEARNING EXPECTATIONS**

The student will:

- 15.1** Join sheet metal duct sections using proper seams and connectors.
- 15.2** Install takeoffs and attach flexible duct to a sheet metal duct system.
- 15.3** Identify and describe the basic types of sheet metal.
- 15.4** Define properties of steel and aluminum alloys.
- 15.5** Describe a basic layout method and perform proper cutting.
- 15.6** Describe proper hanging and support methods for sheet metal duct.
- 15.7** Describe thermal and acoustic insulation principles.
- 15.8** Select, apply and seal the proper insulation for sheet metal ductwork.
- 15.9** Describe guidelines for installing components such as registers, diffusers, grilles, dampers, access doors, and zoning accessories.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 15.1** Joins duct sections and fittings.
- 15.2** Installs takeoffs and attaches flexible duct.

### **SAMPLE PERFORMANCE TASKS**

These are sample projects of the type and scale recommended to address one or more of the learning expectations for this standard. Other projects can be used at the instructor's discretion.

### **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Power Tool Institute (PTI), National Fire Protection Association (NFPA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), American Red Cross, Plumbing Heating and Cooling Contractors (PHCC), National Electrical Manufacturers Association (NEMA), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

## **STANDARD 16.0**

Students will describe fiberglass and flexible duct systems.

### **LEARNING EXPECTATIONS**

The student will:

- 16.1** Fabricate selected duct modules and fittings using the appropriate tools.
- 16.2** Install takeoffs and attach flexible duct to a fiberglass duct.
- 16.3** Identify types of fiberglass duct, including flexible duct.
- 16.4** Describe fiberglass duct and some basic fabrication methods.
- 16.5** Describe the various closure methods for sealing fiberglass duct.
- 16.6** Describe the hanging and support methods for fiberglass duct.
- 16.7** Describe how to repair major and minor damage to fiberglass duct.

### **PERFORMANCE INDICATORS: EVIDENCE STANDARD IS MET**

The student:

- 16.1** Fabricates and assembles fiberglass duct fittings and sections.
- 16.2** Installs takeoffs and attaches flexible duct.

### **SAMPLE PERFORMANCE TASKS**

These are sample projects of the type and scale recommended to address one or more of the learning expectations for this standard. Other projects can be used at the instructor's discretion.

### **INTEGRATION LINKAGES**

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, English IV: Communication for Life, Algebra, Geometry, Technical Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), Multistate Academic and Vocational Curriculum Consortium (MAVCC), National Center for Construction Education Research (NCCER), Occupation Safety and Health Administration (OSHA), Power Tool Institute (PTI), National Fire Protection Association (NFPA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, Air Conditioning and Refrigeration Institute (ARI), American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), Air Conditioning Contractors of America (ACCA), Occupational Safety and Health Administration (OSHA), Refrigeration Service Engineers Society (RSES), American Red Cross, Plumbing Heating and Cooling Contractors (PHCC), National Electrical Manufacturers Association (NEMA), Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

## **HEATING, VENTILATION, AIR CONDITIONING, AND REFRIGERATION (HVAC/R II)**

### **SAMPLING OF AVAILABLE RESOURCES**

- *Core Curriculum*, National Center for Construction Education and Research (NCCER), Prentice Hall, Upper Saddle River, NJ; ©2000. Also known as the Contren materials.
- *HVAC/R Level One*, National Center for Construction Education and Research (NCCER), Prentice Hall, Upper Saddle River, NJ; ©2001. Also known as the Contren materials.
- *HVAC/R Level Two*, National Center for Construction Education and Research (NCCER), Prentice Hall, Upper Saddle River, NJ; ©1995. Also known as the Contren materials.
- *HVAC/R Level Three*, National Center for Construction Education and Research (NCCER), Prentice Hall, Upper Saddle River, NJ; ©1996. Also known as the Contren materials.
- *HVAC/R Level Four*, National Center for Construction Education and Research (NCCER), Prentice Hall, Upper Saddle River, NJ; ©1996. Also known as the Contren materials.
- *Fundamentals of Air Conditioning and Refrigeration*, Multistate Academic and Vocational Curriculum Consortium (MAVCC), Oklahoma Department of Vocational and Technical Education ©1996
- *Residential and Light Commercial HVAC*, Multistate Academic and Vocational Curriculum Consortium (MAVCC), Oklahoma Department of Vocational and Technical Education ©1998
- *Domestic Refrigerator, Freezer, and Window Air Conditioner Service*, Multistate Academic and Vocational Curriculum Consortium (MAVCC), Oklahoma Department of Vocational and Technical Education ©1996
- *ACR Electrical Systems*, Multistate Academic and Vocational Curriculum Consortium (MAVCC), Oklahoma Department of Vocational and Technical Education ©1997
- *Refrigeration & Air Conditioning Technology 4<sup>th</sup> Edition*, Delmar Thomson Learning, Stamford, CT. ©2000
- *Modern Refrigeration and Air Conditioning*, Goodheart-Willcox Company Inc. Tinley Park, IL. ©2000
- *Heating and Cooling Essentials*, Goodheart-Willcox Company Inc. Tinley Park, IL. ©2003
- *Service Application Manual*, Refrigeration Service Engineers Society, Des Plaines, IL
- *Air Conditioning News*, BNP
- Air Conditioning Refrigeration Institute (ARI), [www.ari.org](http://www.ari.org)
- Refrigeration Service Engineers Society (RSES), [www.rses.org](http://www.rses.org)
- *RSES Journal*, RSES

- *Total Quality Curriculum*, National SkillsUSA
- Professional Development Program, National SkillsUSA—[www.vica.org](http://www.vica.org)
- American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE), [www.ashrae.org](http://www.ashrae.org)
- ACCA (Air-Conditioning Contractors Association), [www.acca.org](http://www.acca.org)
- Plumbing-Heating-Cooling-Contractors (PHCC), [www.phccweb.org](http://www.phccweb.org)
- Occupation Safety and Health Administration (OSHA), [www.osha.gov](http://www.osha.gov)
- North American Technician Excellence Inc. (NATE), [www.natex.org](http://www.natex.org)
- Council of Air Conditioning and Refrigeration Educators (CARE), [www.carehvacr.org](http://www.carehvacr.org)
- Power Tool Institute, [www.powertoolinstitute.com](http://www.powertoolinstitute.com)
- Fluke Educators Portal, <http://support.fluke.com/educators>
- **J. W. Harris Co.** [www.jwharris.com](http://www.jwharris.com)
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA) [www.smacna.org](http://www.smacna.org)
- **Various Equipment Manufactures**